[Translation]

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Title of the Invention : BUFFER CONTROL METHOD OF RADIO LINK CONTROL LAYER

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This application is hereby filed pursuant to Article 42 and request for examination is filed pursuant to Article 60 of the Patent Law, respectively.

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[Fee]

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[Attached document]

1. Abstract, Specification (Drawing) -1 copy

[Translation]

ABSTRACT OF THE INVENTION

[Abstract]

The present invention relates to a radio link control (RLC) layer, and more particularly, to a buffer control method of a radio link control (RLC) layer capable of reducing data loss and processing delay by reducing an Super field (SUFI) of an Status protocol data unit (PDU) of an RLC layer. In the conventional art, if delay occurs in transmitting a PDU of a receiving buffer to an upper layer by a sequence in a state that a window size is set to be large, a large amount of data is transmitted to the upper layer at one time. This may cause the data not to be processed in accordance with an air interface speed, thereby causing severe results such as loss of subsequent data. To prevent this, the present invention provides a buffer control method of a radio link control layer for controlling a receiving buffer so as to receive PDU data by an RLC layer, the method comprising: receiving PDU data having a sequence number, by using a receiving buffer, from a transmitting end according to an initially set window size, and transmitting the received PDU data to an upper layer by a sequence; and when data more than a preset amount remains on the reception buffer after the reception, providing time margin to process the PDU data remaining on the receiving buffer, by controlling a window size of data to be subsequently transmitted, by inserting a downward set window size SUFI into a status PDU together with an ACK SUF thereby transmitting the inserted SUFIs to a transmitting end. This may prevent overflow of the receiving buffer, and data loss and processing delay resulting from the data loss.

[Representative Drawing]

FIG. 5

[SPECIFICATION]

[Title of the Invention]

BUFFER CONTROL METHOD OF RADIO LINK CONTROL LAYER

[Brief description of the Drawings]

FIG. 1 shows an Structure of an Status protocol data unit (PDU);

FIG. 2 shows a receiving buffer structure according to a window size;

FIG. 3 shows a basic structure of an Super-field (SUFI), and structures of a window size super-field and an acknowledgement (ACK) super-field;

FIG. 4 is a flowchart showing a first embodiment of the present invention; and

FIG. 5 is a flowchart showing a buffer control method according to the present invention.

**** Explanation for the major reference numerals ****

10: status PDU 20: super-field

30: window super-field 40: ACK super-field

100: upper end 200: RLC

300: lower end 350: air interface

400: network

[Detailed description of the invention]

[Object of the invention]

[Field of the invention and background art]

The present invention relates to a radio link control (RLC) layer, and more

particularly, to a buffer control method of a radio link control (RLC) layer capable of reducing data loss and processing delay by reducing an Super field (SUFI) of an Status protocol data unit (PDU) of an RLC layer.

[Technical object of the present invention]

Nowadays, many efforts are ongoing for research of communication techniques which allow access of multimedia without timely and spatial limitations, and for visible achievements of the research. Development of digital data processing and transmitting techniques has resulted in incorporation of wireless and wire communications, and real-time global data communication systems using artificial satellites. The development of digital data processing and transmitting technique has enabled not only the conventional voice communications, but also network-based real-time transmission of still or moving images, and limitless access of information whenever and wherever regardless or wired or wireless characteristics. IMT-2000 is one of the developed techniques.

The RLC layer of the present invention is an Second layer standardized in the third generation partnership project (3GPP), and indicates a protocol layer which controls a data link. The RLC layer includes an unacknowledged PDU (UMD PDU) used when acknowledgement to a transmitting end is not required after receiving a PDU from a receiving end, and an acknowledged PDU (AMD PDU) used when acknowledgement to a transmitting end is required. For data link control, flow of each PDU is controlled based on a plurality of status variables and windows. The RLC layer controls a flow of each PDU by using several status variables and windows for a data link control. The window denotes a size of a PDU which can be transmitted at one time without an acknowledgement signal, which means a size of a buffer provided at transmitting/

receiving ends. Accordingly, the window and the buffer which will be later explained may be considered as the same thing.

A PDU, a basis unit for transmitting and receiving in the RLC layer, is constructed by adding a header including an Sequence number (SN) to an Service data unit (SDU) transmitted from an upper layer. One PDU can be composed of several SDUs or a part of one SDU.

The PDUs are first stored in the RLC buffer and adjusted to correspond to a transmitting window, thereby being transmitted to the receiving end. The receiving end checks whether an SN of a received PDU is within a receiving window or out of the receiving window. As the result, if the SN of a received PDU is out of the receiving window, it is ignored. Also, if it is within the receiving window, it is checked whether an error of each received PDU exists or not. According to this, status information for informing an acknowledge or a negative acknowledge of each PDU is transmitted to the transmitting end RLC. At this time, the receiving window and the transmitting window have the same size. The transmitting end RLC re-transmits a PDU of a negative acknowledge to the receiving end, in which an Status PDU is used to transmit the status information to the transmitting end RLC.

FIG. 1 shows an Structure 10 of an Status PDU. The structure 10 consists of a D/C bit 1 for selecting data/control, a PDU type filed 2 for selecting a type of a PDU, and a plurality of SUFI fields 3, 4. The SUFI field is composed of 16 bits, and a plurality of SUFI fields may be simultaneously included if necessary. For instance, an ACK SUFI filed and a window size SUFI field may be simultaneously transmitted. Since a plurality of SUFI fields are included, a data ending (NO_MORE) SUFI field is inserted into the last SUFI field. And, a padding field 5 filled with '0' in the rest spaces is further included to the status PDU in order to correspond a size of the status PDU.

Several status variables are used for transmitting and receiving a PDU. An Status variable used for a control of the transmitting RLC includes an Send status variable VT(S), a maximum send status variable VT(MS), an acknowledge status variable VT (A), and a Tx_window_size for denoting a transmitting window size. Herein, the VT(S) corresponds to an Sequence number (SN) of a first PDU except re-transfer PDUs among RLC PDUs to be transmitted next, and the VT(MS) corresponds to an Sequence number of a first PDU among RLC PDUs not to be transmitted next (that is, the receiving end is allowed to receive only up to VT(MS)-1). VT(A) corresponds to an Sequence number of a first PDU among PDUs to be acknowledged next.

The Tx_window_size corresponds to a maximum value of the number of PDUs which can be transmitted at one time without an acknowledgement. The VT(A) forms a lower edge and the VT(MS) forms an upper edge, thereby having a relation of VT(MS) = VT(A) + Tx_window_size.

The VT(S) has an initial value of '0', and the value is increased as one whenever one PDU is transmitted except re-transfer. A PDU only in the Tx_window_size is allowable to be transmitted, so that a minimum value of the SN is the VT(A) and the maximum value thereof is the VT(MS)-1.

In the meantime, the receiving end checks whether each PDU is received or not, and transmits ACK/NAK information to the transmitting end through an Status PDU, thereby demanding re-transfer.

Herein, an SN of a first PDU among PDUs to be transmitted or re-transmitted to the receiving end is called as a receive status variable, VR(R). Also, an SN of a first PDU among PDUs not to be transmitted or re-transmitted to the receiving end is called as a maximum acceptable receive status variable, VR(MR). The VR(R) and the VR(MR) respectively form a lower edge and an upper edge of the receiving window, thereby

having a relation of VR(MR) = VR(R) + Rx_window_size.

Herein, the Rx_window_size is a receiving window size, and generally has the same value as the transmitting window size. Also, a receiving end which will receive transmitted PDUs updates the VR(R) by an SN of a first PDU where an error is generated, and updates the VR(MR) by using the relation of VR(MR) = VR(R) + Rx_window_size.

The transmitting window size is equal to the receiving window size, so that explanations will be given on the basis of the receiving window size.

FIG. 2 shows a size of an RLC RX window, in which each block indicates a PDU. As shown, the Rx_window_size has a length from the VR(R) having an SN of a first PDU to the VR(MR)-1 having an SN of a final PDU, and the length is consistent with a buffer size of each transmitting/ receiving end. By using this buffer, received PDUs are aligned by a sequence number and the aligned PDUs are transmitted to an upper layer.

A transmitting RLC which has received a status PDU in which ACK/NAK information for each PDU is contained updates a value of the VT(A) into a value of the VR(R), and updates a value of the VT(MS) by using the relation of VT(MS) = VT(A) + Tx_window_size. Corresponding to this, the transmitting end re-transmits PDUs required by the receiving end.

The SUFI inserted to the status PDU transmitted to the transmitting RLC by the receiving end after a reception of PDUs is completed in order to inform the Rx/Tx window sizes and ACK information will be explained in more detail.

FIG. 3 shows a general SUFI structure and a window size SUFI and an ACK SUFI structure. As shown, a SUFI 20 is composed of three sub-fields, a type field 21 denoting a kind of a SUFI, a length field 22 denoting a length of a corresponding SUFI, and a value field 23 for a SUFI having a value. According to a kind, the SUFI can use only a part among the type field 21, the length field 22, and the value field 23. For

example, the window size SUFI 30 and an ACK SUFI 40 use only the type field 21 and the length field 22.

The window size SUFI 30 includes a type field 31 of 4 bits denoting a kind of a SUFI (WINDOW). Also, the window size SUFI 30 includes a length field 32 where a window size number (WSN) of 12 bits which means the aforementioned Tx/Rx window size is located. Therefore, an allowable size of a window is theoretically a region of $[0, 2^{12}-1]$.

The ACK SUFI 40 is composed of a type field 41 of 4 bits denoting a kind of a SUFI (ACK), and a length field 42 where an acknowledged last sequence number (LSN) is located. Through this, the transmitting end can check an amount of PDU data acknowledged by a current receiving end.

A type file for indicating a type of a SUFI is composed of 4 bits, and 16 types of SUFIs may be used. According to the standardizations up to now (3G TS 25. 322), 8 types of SUFIs are defined, and 8 types of 1000~1111 are preliminary regions. Here, a value indicating a window size is '0001', which uses a WINDOW as a signal. And, a value indicating acknowledgement is '0010', which uses an ACK as a signal.

Meanwhile, at the time of transmitting and receiving SUDS of PDUs, if PDUs having SDUs remain on a transmitting buffer too long or an error is generated on PDUs, PDUs including the corresponding SDUs are all discarded thus to enhance efficiency of a buffer and a limited radio resource.

If a specific PDU which has been expected to be received according to a sequence number is not received yet, received PDUs are not transmitted to an upper layer even if the PDUs after a corresponding PDU are all received. As a result, a receiving buffer is not made to be empty until the corresponding PDU is received. Accordingly, the receiving end waits for the corresponding PDU while receiving other PDUs. Then, if the

corresponding PDU is received and thereby the receiving buffer is filled, the receiving end transmits an ACK signal to the transmitting end, and arranges data stored in the receiving buffer by a sequence. At this time, the transmitting RLC transmits next PDUs corresponding to the transmitting window size to the receiving RLC by the ACK signal. According to this, if all data in the receiving buffer are not arranged by a sequence before next data are received from the transmitting end, data loss may occur. That is, if the window size is set to be large, the above problems may occur.

As aforementioned, in the case that delay occurs in transmitting the PDU of the receiving buffer to the upper layer by a sequence in a state that the window size is set to be large in the conventional art, a large amount of data is transmitted to the upper layer at one time. This may cause the data not to be processed in accordance with an air interface speed, thereby causing severe results such as loss of subsequent data.

Accordingly, an object of the present invention is to provide a buffer control method of a radio link control (RLC) layer capable of reducing data loss and processing delay, by actively controlling a window size according to a processing speed of a receiving buffer, by adding a proper window size SUFI to a status PDU of an RLC layer which outputs an ACK signal with respect to a received PDU.

[Construction of the present invention]

To achieve these and other advantages and in accordance with the purpose of the present invention, as embodied and broadly described herein, there is provided a buffer control method of a radio link control layer for controlling a receiving buffer so as to receive PDU data by an RLC layer, the method comprising: (a) receiving PDU data having a sequence number, by using a receiving buffer, from a transmitting end according to an initially set window size, and transmitting the received PDU data to an

upper layer by a sequence; and (b) when data more than a preset amount remains on the reception buffer after the reception, providing time margin to process the PDU data remaining on the receiving buffer, by controlling a window size of data to be subsequently transmitted, by inserting a downward set window size SUFI into a status PDU together with an ACK SUF thereby transmitting the inserted SUFIs to a transmitting end.

The buffer control method of a radio link control layer may further comprise: (c) receiving new PDU data by the set window size, arranging the previous PDU data remaining on the buffer by a sequence, and then transmitting the PDU data to an upper layer; (d) after completely receiving the new PDU data, controlling a window size of data to be subsequently transmitted, by inserting a window size SUFI newly controlled according to a margin of the receiving buffer, into a status PDU together with the ACK SUFI, and then by transmitting the SUFIs to the transmitting end; and (e) repeatedly performing the steps (c) and (d) until the window size becomes the initially set window size.

The method according to the present invention will be explained in more detail with reference to FIGS. 4 and 5.

FIG. 4 is a flowchart showing a first embodiment of the present invention, which shows that the present invention is applied to a situation which may occur in a severe case.

A terminal, a receiving end includes an upper end 100, an RLC 200, and a lower end 300. And, the terminal communicates with a network 400, a transmitting end through an air interface 350. In the present invention, a PDU data communication process by the RLC layer 200 will be explained.

First, as aforementioned, a window size is set as a size of $[0, 2^{12}-1]$, thereby

having a very great value as an initial value. Herein, the window size is supposed to have an upper limit as the initial value.

Also, it is supposed that the rest data ([VR(R+1), VR(MR)-1]) have been already received in a state that VR(R) has not been received by receiving PDU data from the transmitting end through an air interface (S10).

The initially set window size (Tx_window_size, Rx_window_size) is the same as that of a transmitting/ receiving buffer, and is set to transmit PDU data of a corresponding size at one time without a reception of an ACK signal. That is, the network 400, the transmitting end inputs PDU data to be transmitted to a transmitting buffer having the same window size as the set window size (Tx_window_size), and sequentially transmits the input PDU data. And, the RLC layer 200 of the receiving terminal receives PDU data, through the receiving buffer, by the set window size (Rx_window_size). Here, each PDU data has a sequence number (SDU), and is sequentially arranged by a sequence. The PDU data arranged by a sequence order is transmitted to the upper end 100. The process is simultaneously performed while receiving PDU data. Also, the RLC layer 200 waits until PDU data having right sequence numbers is received if PDU data having wrong sequence numbers is received. The waiting time can be ignored if a data amount to be arranged by a sequence is less. However, if a re-arrangement data amount is much, waiting time can be long and much data can be transmitted to the upper layer 100 at one time. Accordingly, time to process much data transmitted to the upper layer 100 can be greater than a communication speed process of the air interface 350. In this case, data to be subsequently received may be lost.

The preferred embodiment has a state that the RLC layer 200 has not received data of the VR(R). According to this, even if the RLC layer 200 has received all the rest data, a sequence arrangement for that can not be performed and the rest data can not be

transmitted to the upper layer. In this state, if data of the VR(R) is received and an ACK signal for the currently received content is requested from the transmitting end (S20), it means that a reception of all the PDU data has been completed. Thus, the RLC layer 200 has to transmit an ACK signal for the received PDUs.

Herein, if a status PDU including only an ACK SUFI is transmitted to the transmitting end 400, new PDU data having the same size as the current size will start to be transmitted. However, the current receiving buffer does not have a margin, all of the received PDU data inside the receiving buffer should be arranged by a sequence number thus to be transmitted to the upper end before new data is received. And, the transmitted data has to be completely processed at the upper end before reception of the next data is completed. However, said process may have a possibility of a data loss in case that a buffer size is larger than a data amount that can be processed at the upper layer.

Accordingly, in order to solve this problem, an amount of PDU data to be transmitted next will be controlled through a control method to which the present invention has been applied, after the (A).

In the case that PDUs more than a preset amount remain in the receiving buffer in steps (S10, S20). it is anticipated that time for processing the PDUs will be longer than time which takes for next transmitted data to reach. Accordingly, in order to minimize an amount of data to be newly received while processing currently received PDU data, an ACK SUFI and window size control information are contained in the status PDU which provides ACK information for currently received data information, and then transmitted to the transmitting end (S30). Here, the window size control information is a window size SUFI which has set a window size (WSN) as '1'.

According to the 3GPP communication standard, a desired amount of SUFIs can be inserted into the status PDU, and the receiving end can always change a window size

during a communication connection. Therefore, in order to greatly reduce input of new data, the window size SUFI for transmitting the status PDU having the ACK SUFI and reducing the window size as '1' can be included.

The window size SUFI transmits the ACK signal for the received PDU data to the transmitting end, and at the same time transmits a command to downward control the window size. Accordingly, the transmitting end controls the window size as '1', and thereby transmits PDU data (S40). At this time, data corresponding to one widow size is transmitted, so that an ACK signal is not required from the receiving end whenever a data transmission is completed but the ACK signal is required when predetermined data is transmitted (S50).

Like this, since a size of the next data becomes greatly small, the receiving buffer can accept the next data without loss and the previously received PDU data can be arranged by a sequence thus to be transmitted to the upper end 100. Also, in the upper end 100, the previously received data is processed and next data having a small size can be processed without a problem.

After transmitting predetermined data through the step S50, the transmitting end requests an ACK signal from the receiving end. Then, the receiving end of the terminal checks its buffer state, and contains a window SUFI for ordering a window size to be upward set in the status PDU by an amount of a buffer margin generated due to a decrease of the window size thus to transmit to the transmitting end (S60).

Accordingly, the transmitting end transmits PDU data by a window of a size in the previous steps (S40 and S50), and requires an acknowledgement signal after transmitting proper data. And, the transmitting end newly controls the window size by control information according to a buffer margin in a similar manner to the step (S60), and finally increases up to an initial window size. That is, by adding or subtracting the

amount of PDU data transmitted according to a buffer margin, communication can be controlled within a processing ability of the receiving end thus to prevent a data loss and a time delay.

FIG. 5 is a flow chart of the preferred embodiment of the present invention, in which an inner SUFI of the status PDU transmitted in the RLC layer is used. Herein, an initial window size is set as a predetermined value and the value is supposed to be great.

Firstly, transmitted PDU data corresponding to the initial window size are received, and then it is checked that PDUs more than a predetermined value remain in the buffer. At this time, if remaining PDUs do not exist, the ACK SUFI is contained in the status PDU and then transmitted to the transmitting end.

In the meantime, in case that PDUs more than a predetermined value remain in the buffer after the reception completion, the receiving terminal processes it. At this time, a speed more than an air interface speed of the transmitting/ receiving terminal is required. Also, if new data is received as the initial window size, a data loss can be generated. Therefore, the ACK SUFI and the window size SUFI having a downward set window size are contained in the status PDU and then transmitted to the transmitting end, thereby reducing a window size. Herein, the downward set window size can be '1'.

The receiving end receives next PDUs in a state of the downward set window size. The receiving end has a margin to process already received buffer contents while processing corresponding PDU data due to a reception of data of a small size.

The PDU data of a small size can request ACK information after a predetermined transmission. Herein, the ACK information can be required after one window data is transmitted according to a selection of the transmitting end.

After transmitting predetermined data, if the transmitting end requires ACK information, the receiving end simultaneously transmits an ACK SUFI and an upward set

window size SUFI by referring to a current buffer margin, thereby increasing a window size of a next transmission. If there is no buffer margin, the window size may be maintained or reduced.

As aforementioned, after reducing the window size, by repeating the steps for transmitting an ACK signal according to a buffer margin and properly controlling a window size, the window size is finally restored up to the initial window size. Also, during these successive processes, data to be received is not lost. Accordingly, in the RLC layer communication, by properly using the SUFI that a concrete using method has not been defined, an overflow of a buffer can be prevented.

[Effects of the present invention]

As aforementioned, in the present invention, the window super filed that can be included in the status PDU is positively used to increase or decrease the window size according to a buffer status. Accordingly, overflow of the receiving buffer is prevented, and data loss and time delay due to the data loss may be prevented. In the present invention, a positive using method of the window size SUFI only of which form has been defined was explained, thereby providing affirmative effects on the 3GPP communication standard.

What is claimed is:

1. A buffer control method of a radio link control layer for controlling a receiving buffer so as to receive PDU data by an RLC layer, the method comprising:

(a) receiving PDU data having a sequence number, by using a receiving buffer, from a transmitting end according to an initially set window size, and transmitting the received PDU data to an upper layer by a sequence; and

(b) when data more than a preset amount remains on the reception buffer after the reception, providing time margin to process the PDU data remaining on the receiving buffer, by controlling a window size of data to be subsequently transmitted, by inserting a downward set window size SUFI into a status PDU together with an ACK SUF thereby transmitting the inserted SUFIs to a transmitting end.

2. The method of claim 1, further comprising:

(c) receiving new PDU data by the set window size, arranging the previous PDU data remaining on the buffer by a sequence, and then transmitting the PDU data to an upper layer;

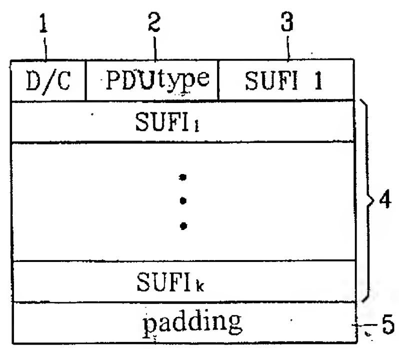
(d) after completely receiving the new PDU data, controlling a window size of data to be subsequently transmitted, by inserting a window size SUFI newly controlled according to a margin of the receiving buffer, into a status PDU together with the ACK SUFI, and then by transmitting the SUFIs to the transmitting end; and

(e) repeatedly performing the steps (c) and (d) until the window size becomes the initially set window size.

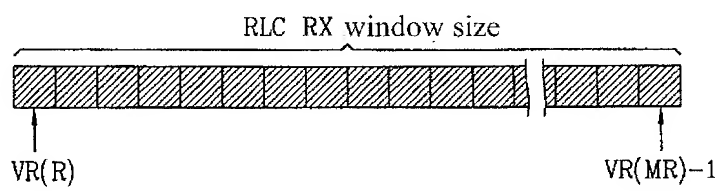
3. The method of claim 1, wherein the downward set window size in the step

of (b) is '1'.

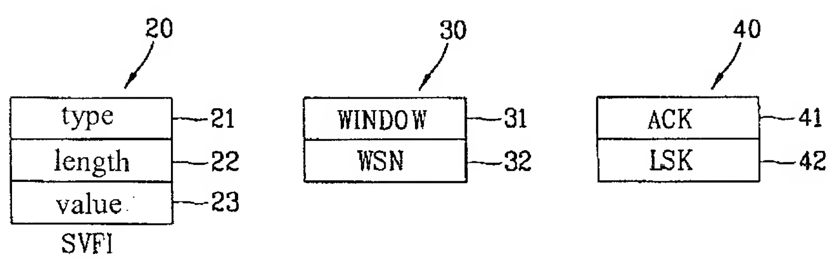
[FIG. 1]



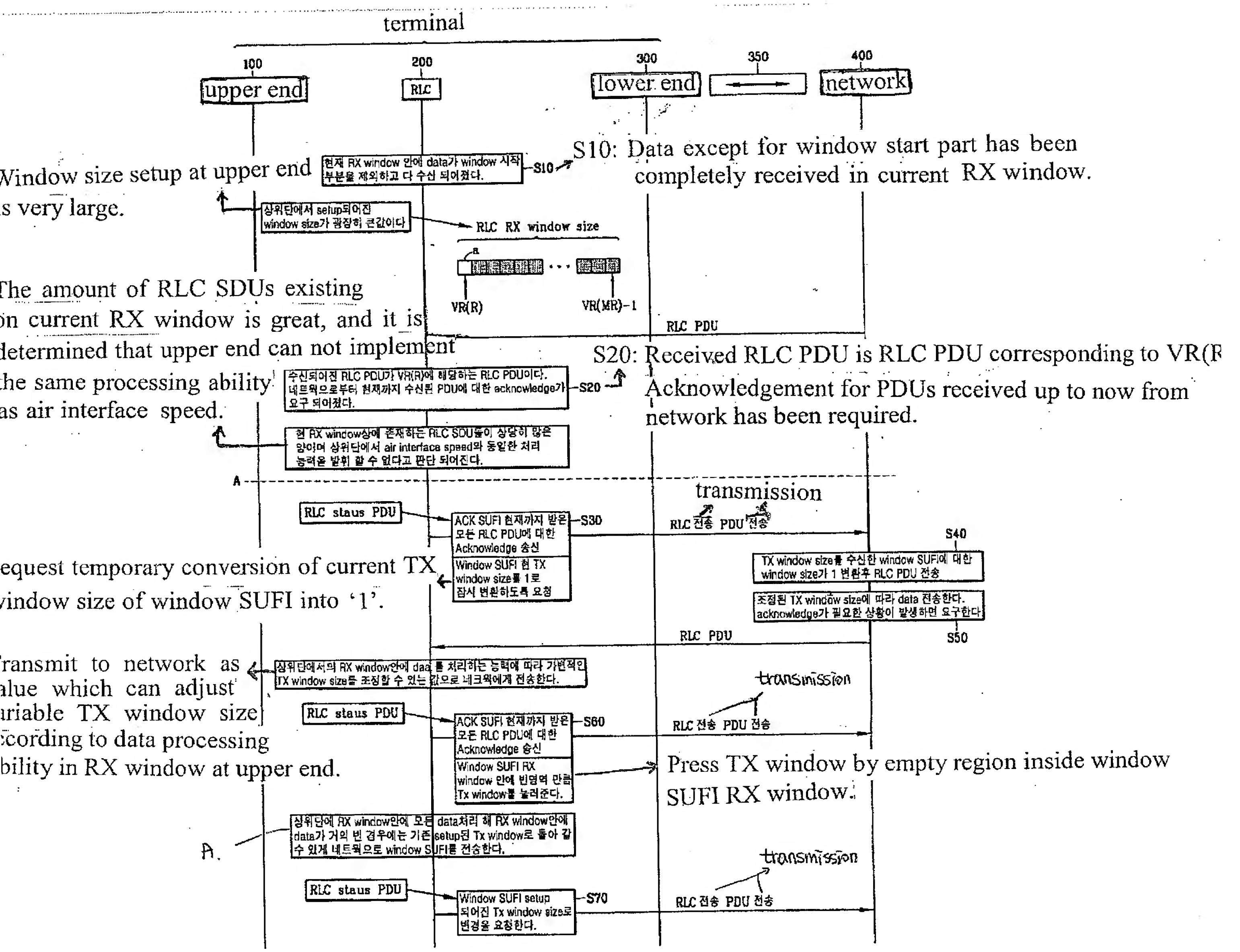
[FIG. 2]



[FIG. 3]



【FIG. 4】



S30 : Transmit ACK SUFI and acknowledge for all RLC PDUs received up to now.

S40: Transmit RLC PDU after converting window size for window SUFI having received Tx window size into ‘1’.

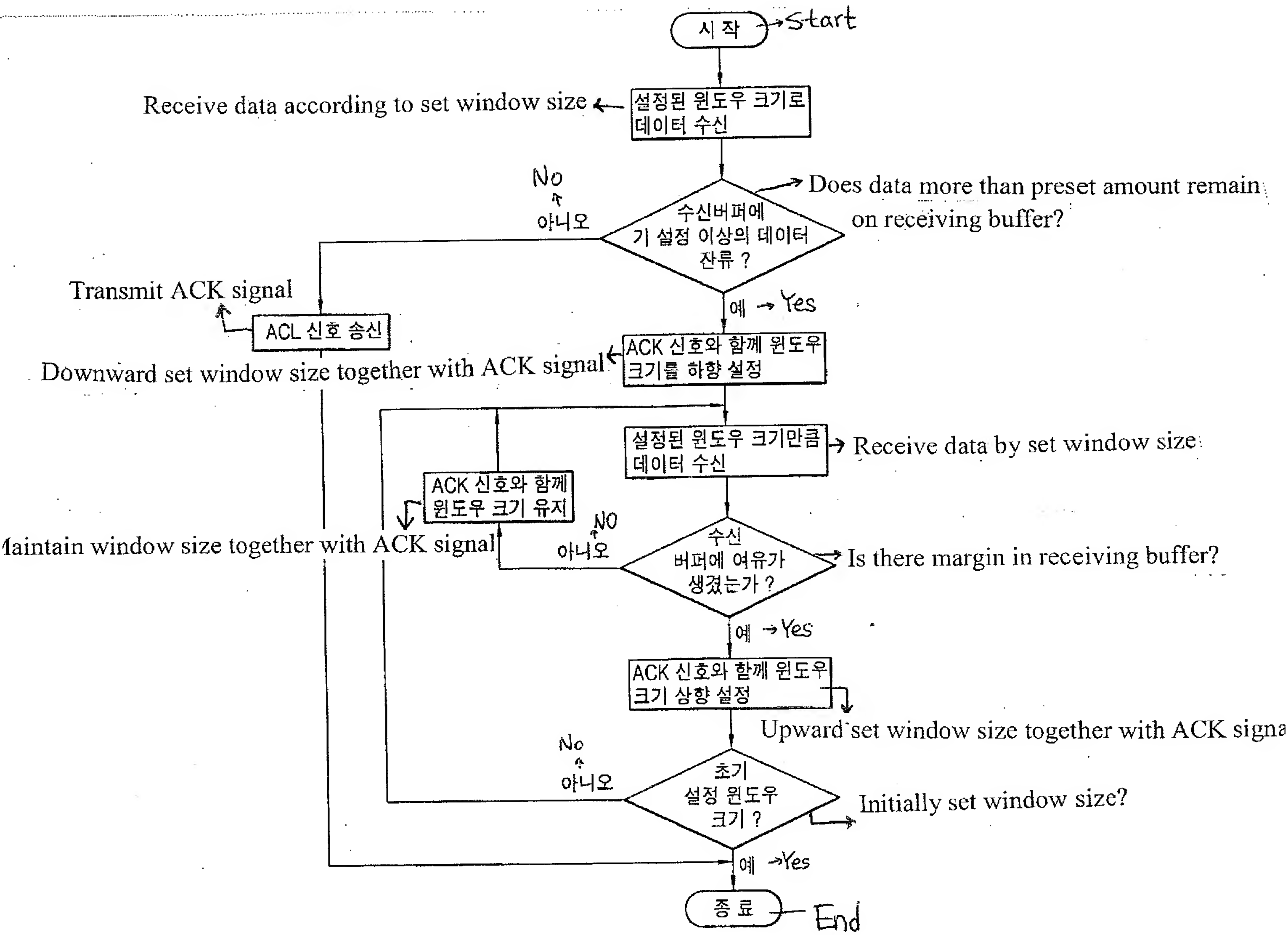
S50: Transmit data according to adjusted TX window size. Request ACK signal if necessary.

S60: Transmit ACK SUFI and acknowledge for all RLC PDUs received up to now.

A: Transmit window SUFI to network for return to already-setup TX window if data inside RX window is almo[st] empty after processing all data inside RX window at upper end.

S70: Request change into TX window size which has been window SUFI setup.

【FIG. 5】



시 작
Start
설정된 윈도우 크기로 데이터 수신
Receive data according to set window size
수신버퍼에 기 설정 이상의 데이터 잔류 ?
Does data more than preset amount remain on receiving buffer?
No
아니오
예
Yes
ACL 신호 송신
Transmit ACK signal
ACK 신호와 함께 윈도우 크기를 하향 설정
Downward set window size together with ACK signal
설정된 윈도우 크기만큼 데이터 수신
Receive data by set window size
ACK 신호와 함께 윈도우 크기 유지
Maintain window size together with ACK signal
NO
아니오
수신 버퍼에 여유가 생겼는가 ?
Is there margin in receiving buffer?
예
Yes
ACK 신호와 함께 윈도우 크기 상향 설정
Upward set window size together with ACK signal
No
아니오
초기 설정 윈도우 크기 ?
Initially set window size?
예
Yes
종 료
End